RULES FOR FORECASTING THE CREST STAGES AT VICKSBURG, MISS., BASED UPON THE STAGES AT CAIRO, ILL.

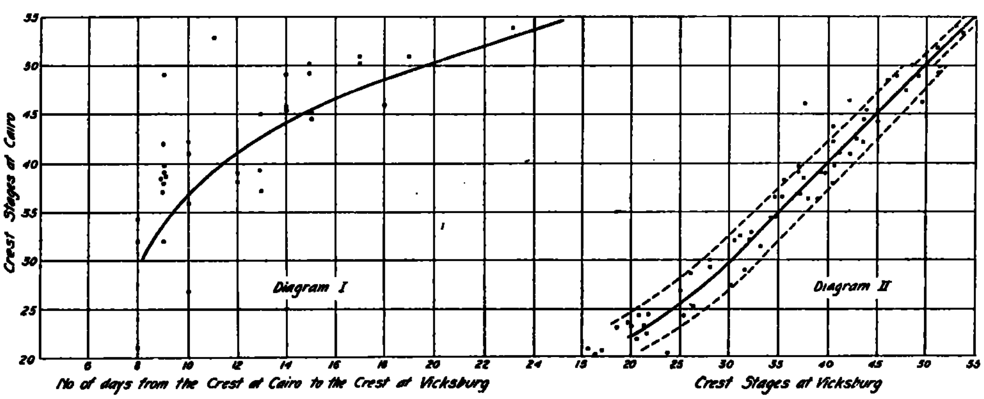
By HERMAN W. SMITH.

[Washington, D. C., October, 1920.]

Vicksburg is 602 miles below Cairo. The velocity of the current at a 25-foot stage is about 3 miles per hour and at a 45-foot stage it is about 4.7 miles per hour. This would give the time for stream flow from Cairo to Vicksburg as 6 days for high stage and about 8 days when the river is at 25 feet.

Figure 1 gives the time intervals for the travel of the crest stages from Cairo to Vicksburg for a large number of crests from 30 to 55 feet at Cairo. It will be seen that the time interval of the crests between the two places does not decrease with the higher velocity of stream flow at higher stages, but the higher the flood crest, the longer it takes for it to reach the lower station. This is probably due to the damming effect of the overflowing of the river banks. The average time for a crest of 30 feet to travel from Cairo to Vicksburg is 8 days, and for a crest of 50 feet, 20 days.

The character of the rise has a marked effect on the time interval for the crest. When the rise is rapid at



FIGS. 1 and 2.—Gage relations, Cairo and Vicksburg—time at left, crest at right.

Cairo and then falls rapidly, the crest will reach Vicksburg from 2 to 8 days sooner than when the rise is long sustained at Cairo after the crest has reached that place. The higher the crest the longer the crest will be delayed.

Figure 2 shows the relative height of the crest stages, Cairo and Vicksburg.

Above 30 feet the average crests are about the same at the two places, but there is a range of about 2 feet on either side of the mean for stages below 50 feet.

When the river falls rapidly at Cairo after the crest reaches that place, the crest stage at Vicksburg will be lower than at Cairo, generally from a few tenths to a foot, but it may be as much as 2 feet when the crest is below 50 feet.

When the streams below Cairo are high and deliver their crests in time to meet the crest from Cairo it will increase the crest stage at Vicksburg, sometimes by as much as a foot or two.

When the rise at Cairo is long sustained and the Mississippi is high above Cairo, the crest stage at Vicksburg will frequently be from a few tenths to as much as a foot higher than at Cairo. With a crest stage below 50 feet the difference may sometimes be as much as 2 feet, if the tributary streams below the Ohio are high.

FLOOD PREVENTION IN THE MINNESOTA VALLEY.

An abstract of the report of Mr. E. V. Willard, Minnesota State Commissioner of Drainage and Waters. (Investigation by Mr. Adolph F. Meyer, consulting engineer; report obtained through courtesy of Mr. H. W. Richardson, meteorologist, Duluth, Minn.)[1]

Some of the conclusions reached by Mr. Meyer are as follows:

(1) Material reduction of devastating floods in the Minnesota River Valley is possible, but some lands must be sacrificed for the benefit of others.

(2) No substantial protection can be accomplished by either levee construction or channel improvement.

(3) Flood protection must and can be accomplished by reservoir construction.

(4) Protection of the valley lands from all floods, including those extraordinary ones of rare occurrence is not worth what it would cost.

(5) The protection of most of the valley lands from frequent flooding is possible and worth more than twice what it will cost.

(6) The best paying project is that which protects the valley lands from all floods except those which may be expected to recur, on an average, once in 10 or 15 years.

(7) Automatic retarding basins are not practicable on the Minnesota River. Manually controlled reservoirs must be used.

(8) No satisfactory reservoir sites are available, on the tributary streams.

(9) Three large reservoirs with a total capacity of eighteen and one-half billion cubic feet can economically be secured for flood prevention purposes in the valley itself.

(10) Although the reservoirs proposed can not retard all the run-off water during extreme floods, the structures themselves must be able to safely meet extreme flood conditions.

(11) Practically all lowlands in the Minnesota River Valley, aggregating about 100,000 acres, are now flooded at least every other year on an average.

(12) The flood protection works proposed will materially benefit over 60,000 acres. Large additional areas will receive minor benefits. This does not include prairie lands to which the valley furnishes ditch outlets.

(13) About 20,000 acres of agricultural lands lying within the reservoirs will be depreciated because they will be flooded more frequently than at present. (This area does not include areas classified as lakes, ponds, sloughs, or marshes on the Government maps based on the surveys of 1909–10.)

(14) On the basis of the available data the cost of the proposed project is estimated at nearly $2,000,000.

(15) Minnesota needs to appropriate funds for topographical surveys and hydrological observations.

(16) All three reservoirs here proposed must be planned and operated as a single system or full benefit will not be derived therefrom.

(17) The reservoirs proposed are for flood prevention purposes and not for power or navigation. They must be operated as intended in order to be effective.

[1] *Bulletin of the Affiliated Engineering Societies of Minnesota*, December, 1920.

An increase in the bankful capacity of the main stream at critical sections is proposed, but channel enlargement to provide for flood-flow capacity is not feasible.

Reservoir sites.—Many of the destructive floods which occur in the Minnesota River Valley are local in character. Flood producing conditions seldom, if ever, occur simultaneously with equal intensity over such large and diverse areas as those included within the Minnesota River drainage basin. Early spring floods caused by the melting of accumulations of snow come nearest to being general throughout the entire valley. The most destructive floods, however, are those which occur during the crop season. Since they are largely due to flood flows from individual tributaries, these summer floods are normally much more severe in one part of the valley than in the remainder. If these floods are to be prevented by retarding the flood waters until the available channels can carry them away, then reservoirs must necessarily be located in various portions of the drainage basin.

Four "reasonably satisfactory" sites for the location of reservoirs were found near Ortonville, Montevideo, Delhi, and New Ulm. Big Stone Lake, near Ortonville, with an area of about 20 square miles, can be used for retarding the flood waters of the Little Minnesota and Whetstone Rivers. These are extremely flashy streams that at times cause much damage in the upper valley.

Lac qui Parle, above Montevideo, area about 4 square miles, constitutes a natural reservoir, which, with Marsh Lake and large adjoining areas of marsh and low-lying agricultural lands, can be utilized for retarding the flood waters of the Lac qui Parle and the Chippewa Rivers.

Near Delhi there is a possible site which could be used for combined power and flood protection, reducing the flood crests of the Yellow-Medicine River and Hawk Creek. The flood protection feature of this project is not considered to be important.

The New Ulm reservoir would store the water above the mouth of the Cottonwood River. This river flows so rapidly that its flood waters now flow up the Minnesota and fill the valley before the upper tributary waters arrive, and the two proposed upper reservoirs would provide only incomplete protection to the valley around New Ulm.

The storage capacity of three of the four proposed reservoirs would be as follows:

Big Stone Lake, 4 billion cubic feet.
Lac qui Parle reservoir, 9 billion cubic feet.
New Ulm, 5.5 billion cubic feet.

A reservoir on the Blue Earth River is thought to be unnecessary, as its flood waters coming from the south usually pass Mankato before the arrival of the Cottonwood water, and retardation of the Blue Earth would only aggravate conditions at Mankato.

Automatically controlled retarding basins, such as those used on the Miami River, are inapplicable to the Minnesota basin, mainly on account of the long duration of the floods and the irregularity of the flood-producing combinations.

On account of the rapidly increasing channel capacity from Big Stone Lake to Mankato, the size of flood protection reservoirs provided per square mile of tributary drainage area should increase *upstream.* The channel below Big Stone Lake, for example, has a capacity only about one-tenth as large as that of the channel below Montevideo, even though the drainage area tributary to Big Stone Lake is one-fifth as great as that tributary to the Minnesota at Montevideo. Such reservoirs should also be relatively larger for small basins than for large ones, because the smaller the area the larger the rainfall and run-off in inches depth over that area, which will occur with given frequency.

In the operation of the proposed reservoirs within the limits of their capacity no water should be discharged from any one of them until it is full, or the stage in the reservoir next below it is falling, indicating that the inflow is less than the outflow. In general, this means that the upper reservoirs should be filled first and emptied last; or, in other words, the storing of water should continue in the upper reservoirs until wasting has begun in the reservoir next below. During sudden freshets on the tributaries between any two reservoirs the wasting of flood water from the reservoir above should be temporarily suspended.

The report also contains interesting paragraphs on probable flood frequency in the Minnesota River Valley, the economic value of flood protection, meteorological tables, and other flood statistics. It is the opinion of Mr. Meyer that floods like those in the upper valley in 1919 are not likely to be approached oftener than once in 40 years, and that bankful stages are probable every year in the lower valley and every two years above. Tables and curves were used to form an estimate of the depreciation of cultivated lands by flooding during the crop season, and they indicate that land on which a grain crop is lost once in every three years has no capital value for cultivation purposes. As flood losses become less frequent, land values increase rapidly until only one crop is lost every 10 or 15 years; beyond this point the increase in capital value is very slow.—*H. C. F.*

THE INFLUENCE OF FOREST AREAS IN NONFORESTED REGIONS UPON EVAPORATION, SOIL MOISTURE, AND MOVEMENT OF GROUND WATER.[1]

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[Author's Abstract.]

[Read before Iowa Academy of Sciences, Annual meeting, 1920.]

The paper includes the results of a series of studies carried on in the northeastern part of Iowa during the summer of 1919. The work covers the comparison of the evaporation and soil moisture conditions obtaining on forested and nonforested sites, and the influence that the forested areas have as to the checking of run-off, the absorption of moisture into the soil, and the response of the various soils at various depths to precipitation.

The direct influence of forest cover in checking the rate of evaporation is emphasized, there being a distinct decrease in evaporation with the succession from open to brushy and in turn to timbered sites. There is also evident a rather direct relation between the rate of evaporation and the aspect of slopes, and between the evaporation and the wind velocity.

The studies of soil moisture show the tendency of the timbered soils to a higher moisture content and the greater absorbtive qualities. There is apparent a direct relation of the forest cover to the checking of the run-off and to the rate of permeability of soil moisture to the lower soil layers. The movement of ground water appears to be distinctly retarded in the case of the timber soils. The results all indicate the importance of forest cover on the slopes of watersheds, even where the forest areas are comparatively limited in extent.

[1] To be published at Des Moines, Iowa, in the *Proceedings of the Iowa Acad. of Sci.*, for 1920.